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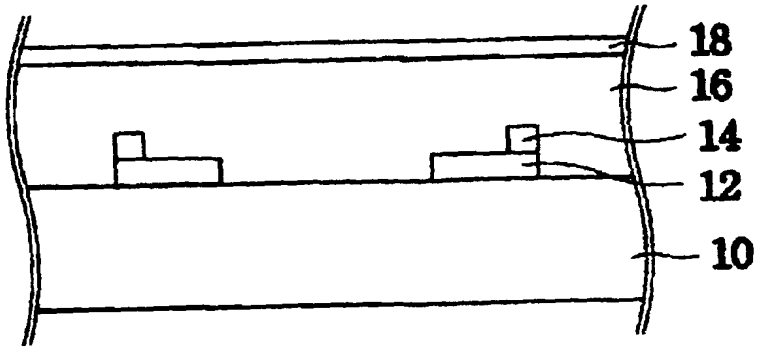
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: PLASMA DISPLAY PANEL



(57) Abstract: A plasma display panel which efficiency can be maximized by improving a protective layer of a front substrate using a material with a superior coefficient of secondary electron emission, and which can have a longer life by protecting phosphor layers from ion-impact through phosphor layers with a material having a higher hardness and a superior coefficient of secondary electron emission. The protective layer on the front substrate is formed of carbon nanotubes, or a carbon nanotube protective layer is formed of carbon nanotubes on the outer surface of the protective layer. Further, a phosphor protective layer is formed on the outer surface of the phosphor layers using diamond-like carbon(DLC) and/or a-CNx.

WO 01/31673 A1

Title of the Invention

PLASMA DISPLAY PANEL

Technical Field

The present invention relates to a plasma display panel, and more particularly, to a plasma display panel which efficiency can be maximized by improving a protective layer of a front substrate using a material with a superior coefficient of secondary electron emission, and which can have a longer life by protecting phosphor layers from ion-impact through phosphor protective layers formed of a material having a higher hardness and a superior coefficient of secondary electron emission.

Background Art

In general, a plasma display panel displays characters or graphics by using ultraviolet light generated from a plasma, which is divided into a AC plasma display panel and a DC plasma panel in accordance with the structure of electrodes therein. Also, there may be a mixed type plasma display panel in which the AC plasma display panel and the DC plasma display panel are combined.

FIG. 1 shows a structure of the most widely used AC PDP as a schematic partial section. As shown in FIG. 1, the prior art AC

plasma display panel comprises a front substrate 10 on one surface of which multiple pairs of transparent sustain electrodes 12 and 12 are formed and multiple black stripes 12a are formed between said multiple pairs of sustain electrodes 12 and 12. Multiple pairs of bus electrodes 14 are formed on the multiple pairs of sustain electrodes 12 and 12, respectively, and the electrodes and buses are covered with a dielectric layer 16, on which a protective layer 39 is formed.

On one surface of a rear substrate 30, which confronts the one surface of the front substrate 10 in a spaced apart parallel relationship, multiple address electrodes 32 and 32 are arranged so as to extend in a direction passing by, preferably orthogonal to, the multiple pairs of sustain electrodes 12 and 12. The multiple address electrodes 32 and 32 are also covered with a dielectric layer 34. Each intersection of each pair of sustain electrodes 12 and 12 and each address electrodes 32 and 32 defines a single cell, which is separated by multiple barrier ribs 36 formed between the front substrate 10 and the rear substrate 30. Multiple phosphor layers 38, which are formed on the dielectric layer 34 between each of the barrier ribs 36 and of a constant

layer thickness mainly by a screen printing process. The barrier ribs 36 have characteristics of a reflection layer and an object for supporting the front substrate 10 after being assembled, besides an object for preventing from a cross talk between adjoining cells. Said barrier ribs 36 may be formed of stripe shapes at a constant distance in parallel to, and between, said address electrodes 32 and 32, or may be formed of a matrix shape surrounding each of said discharge cells.

In such an AC PDP structure, the transparent X and Y sustain electrodes 12 and 12 for a sustain discharge, the black stripes 12a, the bus electrodes 14, the transparent dielectric layer 16, and the protective layer 39 of magnesium oxide(MgO) are formed in order on said one surface of the front substrate 10 of a glass material for displaying.

On the opposite rear substrate 30, the address electrodes 32 and 32, the dielectric layer 34, the barrier ribs 36 and the phosphor layers 38 are formed in order so as to enter addressing data. Then, the plasma display panel is assembled by sealing two substrates 10 and 30 at the edge, evacuating the cavity between the two substrates 10 and 30, and filling the cavity with

discharge gas.

Light is emitted when electrons of phosphor particles in the phosphor layers 38 are returned to the ground state after being changed from a ground state to an energized state by an external stimulus. And the color of the emitted light is determined by a very small amount of activators which are contained in the phosphor particles and function as center in emitting light.

Meanwhile, since a protective layer is not covered with the phosphor layers 38, the phosphor particles are deteriorated by an ion impact while discharge is performed in such a plasma display panel structure, thus causing characteristic deterioration of phosphor particles from long use of a plasma display panel.

Where the phosphor layers 38 are covered with a MgO layer, there is one problem in that it absorbs 147nm ultraviolet rays and the brightness is highly lowered.

Furthermore, while the protective layer 39 on the front substrate 10 is formed of magnesium oxide(MgO) on the transparent dielectric layer, mainly by electron-beam vapor deposition process or sputtering process, it is the root cause of lowering efficiency

in the plasma display panel that such protective layer 39 has a low coefficient of secondary electron emission.

Disclosure of Invention

Accordingly, in view of several problems of the conventional arts mentioned above, an object of the present invention is to provide a plasma display panel which efficiency can be maximized by using a material with a superior coefficient of secondary electron emission so as to improve a protective layer of a front substrate, and which can have a longer life by protecting phosphor layers from ion-impact through phosphor protective layers formed of a material having a higher hardness and a superior coefficient of secondary electron emission.

To achieve the above object, in accordance with one embodiment of the present invention, there is provided a plasma display panel having a front substrate of a glass material which comprises multiple transparent electrodes, multiple bus electrodes, multiple black stripes, a dielectric layer, and a protective layer are formed in order on one surface thereof, said plasma display panel being characterized in that said protective layer is formed of carbon nanotubes, or a carbon nanotube

protective layer is formed of carbon nanotubes on the outer surface of the conventional protective layer. Preferably, a rare-earth element, oxigen or nitrogen may be doped with on the outer surface of the carbon nanotube protective layer so as to increase the insulation characteristics.

Further, in accordance with another embodiment of the present invention, there is provided a plasma display panel having a rear substrate of a glass material, which comprises multiple address electrodes and a dielectric layer on one surface thereof, multiple barrier ribs to support the front substrate, and multiple phosphor layers formed between each of the barrier ribs on the dielectric layer, said plasma display panel being characterized in that a phosphor protective layer is formed on the outer surface of the phosphor layers. It is preferred that the phosphor protective layer is formed using diamond-like carbon(DLC) and/or a-CNx, and formed by a chemical vapor deposition(CVD) process.

Brief Description of the Drawings

FIG. 1 is a partially sectional schematic view of a conventional plasma display panel.

FIG. 2 is a partially sectional view illustrating a front

substrate of a plasma display panel in accordance with a first embodiment of the present invention.

FIG. 3 is a partially sectional view illustrating a front substrate of a plasma display panel in accordance with a second embodiment of the present invention.

FIG. 4 is a partially sectional view illustrating a rear substrate of a plasma display panel in accordance with a third embodiment of the present invention.

Best Mode for Carrying out the Invention

Several embodiments of the present invention will be explained in detail with reference to the drawings.

FIG. 2 illustrates, upside down, a front substrate 10 of a plasma display panel in accordance with a first embodiment of the present invention in the reverse direction.

On the front substrate 10 of a glass substrate, sustain electrodes 12 and 12(X and Y electrodes) are formed of ITO mainly by sputtering. On the sustain electrodes 12 and 12, bus electrodes 14 for compensating the resistance of the sustain electrodes 12 and 12 are formed mainly by a screen printing with Cr-Cu-Cr or Ag paste.

A transparent dielectric layer 16 is formed on the exposed surface of the sustain electrodes 12 and 12 and the bus electrodes 14(the upper surface in FIGs. 2 and 3) so as to ensure an insulation characteristic during discharging. Then, directly on the exposed surface of the dielectric layer 16 in this embodiment, there is formed a protective layer 18 of carbon nanotubes having a superior coefficient of secondary electron emission. The protective layer 18 may be deposited by a chemical vapor deposition(CVD) process, etc. In common, the carbon nanotube is made by an electric discharge process, a laser vapor deposition, a pyrolysis vapor deposit process, thermochemical vapor deposition and growing process, a plasma-chemical vapor deposition process, etc., and is divided into a single wall structure and a multi-wall structure according to transition metal used during the process. And in the past, it is difficult to grow the protective layer 18 directly on the glass substrate in the plasma display panel or to form it in the high temperature process. However, it is possible to grow the protective layer 18 in the recent low temperature process.

FIG. 3 illustrates, upside down, the front substrate 10 of

the plasma display panel in accordance with a second embodiment of the present invention in the reverse direction. Similarly to FIG. 2, sustain electrodes 12 and 12(X and Y electrodes) are formed on the front substrate 10 of a glass substrate, and then bus electrodes 14 are formed on the sustain electrodes 12 and 12. Also, a transparent dielectric layer 16 is formed on the exposed surface of the sustain electrodes 12 and 12 and the bus electrodes 14.

And, a protective layer 19 is formed of magnesium oxide(MgO) on the exposed surface of the dielectric layer 16, and then, on the exposed surface of the protective layer 19, there is formed a carbon nanotube protective layer 20 of carbon nanotubes having a superior coefficient of secondary electron emission. The carbon nanotube protective layer 20 may also be formed by a chemical vapor deposition(CVD) process, etc.

In FIGs. 2 and 3, said carbon nanotubes to be grown into a tube shape from C_{60}, are stronger than 1,000 times of iron in hardness, and is excellent to be used as protective layer. Also, said carbon nanotubes is very excellent in the secondary electron emission characteristics, thereby lowering the discharge voltage

and maximizing the efficiency of the plasma display panel where the carbon nanotube protective layer is used instead of a MgO protective layer, or where the carbon nanotube protective layer is formed on the MgO protective layer.

And, it is preferred that the outer or exposed surface of the carbon nanotube protective layer 18 or 20 in FIGs. 2 and 3 is doped with a rare-earth metal, oxigen(O) or nitrogen(N), etc., so as to increase the insulation characteristics.

In such a structure, the protective layer 39 is formed of carbon nanotubes, or a carbon nanotube protective layer is formed on the exposed or outer surface of the protective layer, thereby improving the sputtering-resistance characteristics of the protective layer, and also, enhancing the efficiency of the discharge in the plasma display panel due to the superior coefficient of secondary electron emission. Thus, the driving voltage of the plasma display panel, and the energy consumption, can be lowered, thereby being capable of extending the use life of the plasma display panel longer.

FIG. 4 illustrates a rear substrate 30 of the plasma display panel in accordance with a third embodiment of the present

invention. In FIG. 4, multiple address electrodes 32 and 32 are arranged on one surface of the rear substrate 30, which confronts the one surface of the front substrate 10 in a spaced apart parallel relationship, so as to enter addressing data on the rear substrate 30. On the outer or exposed surface of the multiple address electrodes 32 and 32, there is formed a dielectric layer 34 for protecting the address electrodes 32 and 32 from the ion impact.

Multiple barrier ribs 36 are formed on outer or exposed surface of the dielectric layer 34 in stripe shapes, rectangular shapes, etc., so as to have characteristics as reflection layer, to support the front substrate 10 after being assembled, and to prevent from a cross talk between adjoining cells. Multiple phosphor layers 38, which are formed on the dielectric layer 34 between each of the barrier ribs 36. Then, in accordance to the third embodiment of the present invention, a phosphor protective layer 40 of a constant thickness is formed on the outer or exposed surface of the phosphor layers 38 with a material of high hardness and high light-transmissivity(for examples, diamond-like carbon(DLC), a-CNx).

Such a DLC or a-CNx has a very excellent hardness compared with other material films, thereby enduring the ion impact sufficiently and being able to be formed of a shallow thickness. Also, the phosphor protective layer can be formed easily by chemical vapor deposition.

Further, the driving voltage can be lowered due to the secondary electron emission from the DLC or a-CNx. Commonly in the plasma display panel, a MgO layer is used as the protective layer of the dielectric layer 16 so as to prevent from damage of the dielectric layer 16 by the ion impact. As described in the background art, if the phosphor layers 38 are covered with a MgO layer, there would be one serious problem in that they absorb 147nm vacuum ultraviolet(VUV) rays and the brightness be highly lowered. The above-mentioned problem cannot arise since the DLC or a-CNx employed in the present invention emits electrons secondarily in the contrary to the MgO layer.

As above-described in detail, according to the construction and effects of the present invention, there can be obtained several advantages that the running life of the plasma display panel can become longer by coating phosphor layers with a

material having a higher hardness and strong against the ion impact, and that the sustain voltage can be lowered due to secondary electron emission from the phosphor protective layer.

Various modifications of the disclosed embodiment, as well as alternate embodiments, may become apparent to those skilled in the art without departing from the scope and spirit of the invention as defined by the appended claims.

Claims:

1. A plasma display panel having a front substrate of a glass material which comprises multiple transparent electrodes, multiple bus electrodes, multiple black stripes, a dielectric layer, and a protective layer are formed in order on one surface thereof, said plasma display panel being characterized in that said protective layer is a carbon nanotube protective layer formed of carbon nanotubes.

2. A plasma display panel according to claim 1, wherein a rare-earth element, oxigen or nitrogen is doped with on the outer surface of the carbon nanotube protective layer so as to increase the insulation characteristics.

3. A plasma display panel having a front substrate of a glass material which comprises multiple transparent electrodes, multiple bus electrodes, multiple black stripes, a dielectric layer, and a protective layer are formed in order on one surface thereof, said plasma display panel being characterized in that a carbon nanotube protective layer is formed of carbon nanotubes on the outer surface of the protective layer.

4. A plasma display panel according to claim 3, wherein a

rare-earth element, oxigen or nitrogen is doped with on the outer surface of the carbon nanotube protective layer so as to increase the insulation characteristics.

5. A plasma display panel having a rear substrate of a glass material, which comprises multiple address electrodes and a dielectric layer on one surface thereof, multiple barrier ribs to support the front substrate, and multiple phosphor layers formed between each of the barrier ribs on the dielectric layer, said plasma display panel being characterized in that a phosphor protective layer is formed on the outer surface of the phosphor layers.

6. A plasma display panel according to claim 5, wherein said phosphor protective layer is formed using diamond-like carbon(DLC) and/or a-CNx.

7. A plasma display panel according to claim 5, wherein said phosphor protective layer is formed by a chemical vapor deposition(CVD) process.

FIG. 1

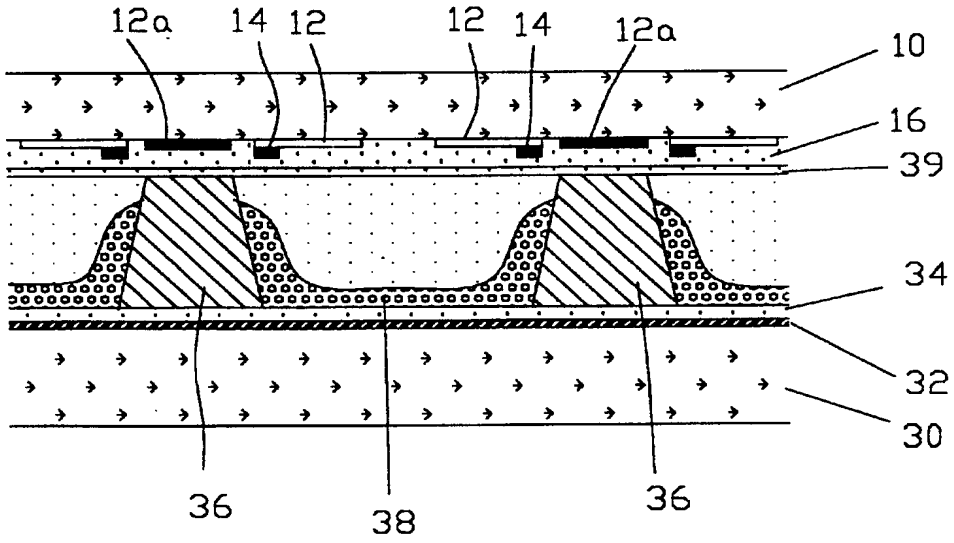


FIG. 2

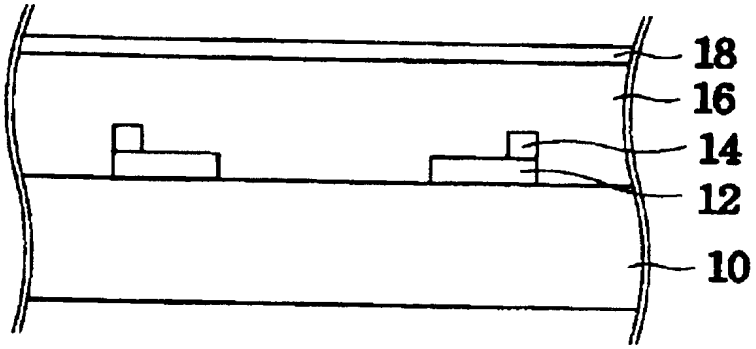


FIG. 3

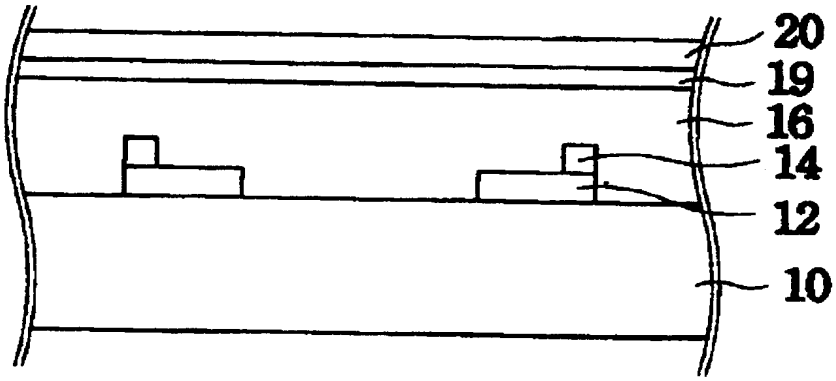
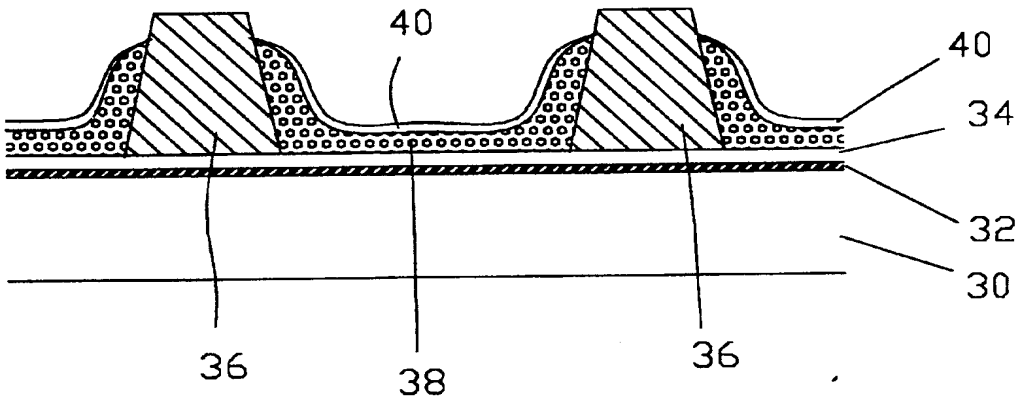


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR00/01204

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H01J 17/49, H01J 11/02, H01J 9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 H01J 17, H01J 11, H01J 9

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and applications for inventions since 1975
Korean Utility models and applications for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5838398 A (TEKTRONIX, INC.) 17 November 1998 claims 1-13; col. 3, lines 27-62; Fig. 3	1-4
Y	JP 9-120778 A (AT&T CORP.) 6 May 1997 claim 1; paragraphs [0017]-[0046]; Figs. 2-9	6, 7
Y	JP 8-339767 A (FUJITSU) 24 December 1996 claim 1; paragraphs [0017],[0018], [0027]-[0050]; Figs. 1-3	6, 7
X Y	JP 1-255130 A (FUJITSU GENERAL) 12 October 1989 page 2, lower right column, lines 2-13; Fig. 2	5 6, 7
A	EBBESEN et. al. 'Large-scale synthesis of carbon nanotubes' NATURE, 16 July 1992, Vol. 358, pp. 220-222	1-4
A	WALT et. al. 'A carbon nanotube field-emission electron source' SCIENCE, 17 November 1995, Vol. 270, pp. 1179-1180	1-4

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevence
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 JANUARY 2001 (20.01.2001)	22 JANUARY 2001 (22.01.2001)

Name and mailing address of the ISA/KR	Authorized officer
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Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5747

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR00/01204

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5838398 A	17. 11. 1998	None	
JP 9-120778 A	6. 5. 1997	EP 764965 A2 EP 764965 A3	26. 3. 1997 28. 1. 1998
JP 8-339767 A	24. 12. 1996	None	
JP 1-255130 A	12. 10. 1989	None	

DERWENT-ACC-NO: 2001-328722

DERWENT-WEEK: 200166

TITLE: Plasma display panel includes a front glass substrate having a protective layer made of carbon nanotubes

INVENTOR: KIM J G; KWON Y G ; KWON Y K

PATENT-ASSIGNEE: ORION ELECTRIC CO LTD[ORION]

PRIORITY-DATA: 1999KR-047241 (October 28, 1999) , 1999KR-047242 (October 28, 1999)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE
WO 0131673 A1	May 3, 2001	EN
KR 2001039030 A	May 15, 2001	KO
KR 2001039031 A	May 15, 2001	KO

DESIGNATED-STATES: CN JP US AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
WO2001031673A1	N/A	2000WO-KR01204	October 24, 2000
KR2001039030A	N/A	1999KR-047241	October 28, 1999
KR2001039031A	N/A	1999KR-047242	October 28, 1999

INT-CL-CURRENT:

TYPE	IPC DATE
CIPS	H01J17/49 20060101

ABSTRACTED-PUB-NO: WO 0131673 A1

BASIC-ABSTRACT:

NOVELTY - A plasma display panel includes a front glass substrate (10) having multiple transparent electrodes (12), multiple bus electrodes (14), multiple black stripes, a dielectric layer (16), and a protective layer (18). The protective layer is made of carbon nanotubes.

USE - As a plasma display panel.

ADVANTAGE - The carbon nanotube protective layer is formed on the outer surface of the protective layer, thus improving the sputtering-resistance characteristics of the protective layer, and enhances the efficiency of the discharge in the plasma display panel due to the superior coefficient of secondary electron emission. Thus, the driving voltage of the plasma display panel and the energy consumption can be lowered, thus the panel is capable of extending its use life longer.

DESCRIPTION OF DRAWING(S) - The figure shows a partially sectional view illustrating the front substrate of a plasma display panel.

Front substrate (10)

Transparent electrodes (12)

Bus electrodes (14)

Dielectric layer (16)

Protective layer (18)

EQUIVALENT-ABSTRACTS:

ELECTRONICS

Preferred Components: The plasma display panel may also include a rear glass substrate comprising multiple address electrodes, a dielectric layer, multiple barrier ribs to support the front substrate, and multiple phosphor layers formed between each of the barrier ribs on the dielectric layer. The plasma display panel has a phosphor protective layer formed on the outer surface of the phosphor layers.

INORGANIC CHEMISTRY

Preferred Materials: A rare-earth element, oxygen or nitrogen is doped on the outer surface of the carbon nanotube protective layer so as to increase the insulation characteristics. The phosphor protective layer is formed by chemical vapor deposition using diamond-like carbon (DLC) and/or a-CNx.

CHOSEN-DRAWING: Dwg.2/4

TITLE-TERMS: PLASMA DISPLAY PANEL FRONT GLASS SUBSTRATE PROTECT LAYER MADE CARBON

DERWENT-CLASS: L03 V05

CPI-CODES: L03-C04;
EPI-CODES: V05-A01A7;

SECONDARY-ACC-NO:
CPI Secondary Accession Numbers: 2001-100822
Non-CPI Secondary Accession Numbers: 2001-236570